SHORT REPORT

How should the chest wall be opened at necropsy?

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Aims: To compare several different instruments used to open the chest wall during necropsy and to assess whether any one type reduced the production of sharp rib ends and thus the potential for receiving an injury.
Methods: During the necropsy the pathologist opened the chest wall using two randomly assigned instruments from a selection of hand saw, electric saw, rib shears, and bread knife. The age, weight, sex, and height of the deceased were recorded, in addition to the textures of the resultant exposed rib ends. During the procedure, the speed, length, production of spray, and site of incision were also noted. The thoracic cavity was inspected and any details of tumours, adhesions, fluid, or organ damage were noted.
Results: Twenty four necropsies were carried out on an equal number of men and women. The total number of ribs that were incised was 422, with 206 through the bony aspect (49%). Sixty seven per cent of the bony rib ends were rough, and this was found to be instrument dependent. The rib shears produced the highest number of rough bony and cartilage rib ends. The electric saw produced the smoothest contoured rib ends. Spray occurred in 29% of cases, exclusively with the use of the electric saw. Organ damage was most frequently associated with the use of the bread knife.
Conclusion: Rib shears, the instrument most frequently used to open the chest wall, appear to cause the highest frequency of rough, potentially dangerous rib ends. The electric saw produced the smoothest rib ends, both in cartilage and bone, and thus seems to offer the most efficacious method of reducing the potential hazard associated with ragged, spiky bone ends during the opening of the thoracic cavity. Although each of the procedures detailed in this study was shown to have its own advantages and disadvantages, personal preference and operator experience are perhaps the most important factors in ultimately determining the method used.

During a necropsy it is necessary to open and remove the anterior breast plate composed of the sternum and rib attachments to inspect and remove the thoracic viscera. This procedure is carried out by disarticulating both of the sternoclavicular joints and cutting through the anterior aspect of the ribs or costal cartilages. The first rib may be sawn through separately from the rest of the rib cage at the start of the procedure,[1 2] although it can be left untouched until the end of the necropsy to avoid damage to the adjacent large vessels.[3–5]

The chest wall can be opened using several instruments including an electric oscillating saw, hand saw, rib shears, bread knife, bone scissors, cartilage knife, or large bladed scalpel (PM40).[1 3 6 7] As a result of this procedure, the cut ends of the ribs present a potential health hazard to the pathologist during the thoracic evisceration and to the technician during reconstitution because they may be sharp and irregular. Although steps can be taken to protect oneself against injury by placing material over the rib end—for example, the loose thoracic skin flap or a mortuary towel—or by leaving "cartilage caps" on the ribs,[6] these methods are not often used. The use of protective hand wear—for example, Kevlar® or chain metal gloves—will reduce the incidence of cuts, but these items are not designed to withstand puncture wounds.

A small sample study was performed to investigate whether or not the use of any one instrument could reduce the risk of puncture injury by producing smooth cut rib ends. These results are presented along with a discussion of the relative benefits and disadvantages of each method used.

METHODS

A small sample qualitative study was performed at the Medico-Legal Centre, Sheffield. A proforma was designed on which the age, weight, height, and sex of the deceased was recorded. Necropsies were randomly assigned to three consultant pathologists (pathologists 1–3) by an independent observer. The pathologists were instructed at the time of necropsy which instrument they were to use to open each side of the anterior chest wall. The instruments used in our study were a Medezine Saterelle hand saw, a Medezine Swordfish 4000 electric oscillating saw, a serrated "Kitchen Devil" bread knife, and Medezine unmodified rib shears (fig 1). The observer recorded the time taken to open each side of the chest wall and the length of each incision. The pathologist then provided an assessment of the findings during and after opening

Figure 1 The instruments used in our study. From left to right: a "Kitchen Devil" bread knife, rib shears, an oscillating saw, a handsaw.

Figure 2 The chest wall incision showing irregular ends of the ribs.

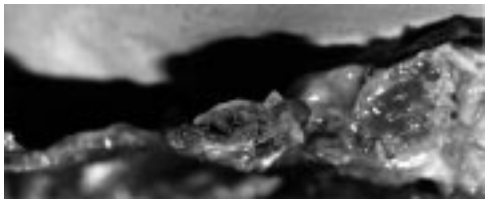

Figure 3 A rough rib end.

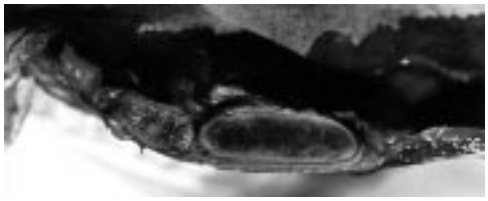

Figure 4 A smooth rib end.

the chest wall, in particular the presence or absence of any adhesions, tumours, or fluid, and the production of aerosol spray. Fluid was defined as any appreciable collection of liquid within the pleural cavity that on opening of the chest could potentially produce an aerosol spray, and spray was defined as visible liquid or tissue particles travelling through the air. Once the chest had been opened the observer recorded which ribs had been cut through, whether the pathologist had cut through bone or cartilage, and whether or not there had been any damage sustained to underlying organs during the procedure. Glove injuries were not assessed in our study. To ensure that the resulting rib edge contour resulted from the instrument used and not any pre-existing bone pathology, different instruments were used on each side in each individual case.

The rib ends were assessed on their appearance to the naked eye and designated rough or smooth. A smooth end was defined as one with a regular contour and no sharp edges, whereas a rough end was one that had the potential to cause injury because of sharp or irregular protruding pieces (figs 2–4).

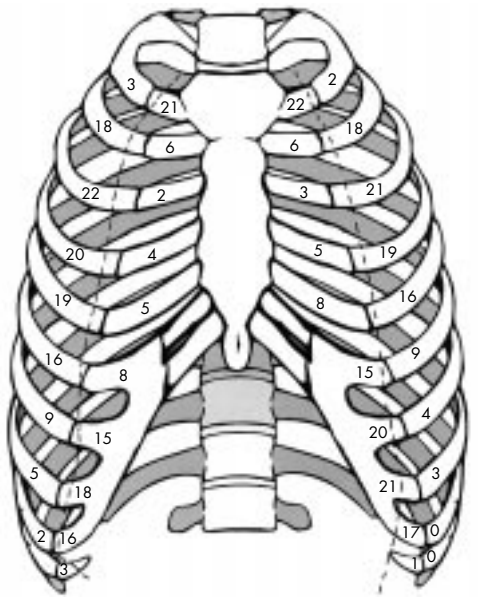

Figure 5 A diagrammatic representation of the frequency of the site of incision to each rib (numbered). The dotted line represents the mean incision made for all cases.

The data were then anonymised, coded by the independent observer, and entered into the computerised statistical package, SPSS®. They were analysed using descriptive statistics.

RESULTS

In total, 24 necropsies were performed under the legal authority of Her Majesty's coroner. We studied an equal number of

Table 1 Incidence of rough and smooth rib ends; mean incision lengths, times, and speeds; thoracic cavity incidence of fluid, adhesions, tumours, spray, and organ damage; and approximate costing for the instruments used in the study

	Hand saw			Electric saw			Rib shears			Bread knife		
	Right	Left	Total	Right	Left	Total	Right	Left	Total	Right	Left	Total
Rough bone	20	20	40	12	10	22	30	19	49	8	18	26
Smooth bone	16	3	19	16	5	21	1	11	12	11	6	17
Rough cartilage	1	1	2	1	0	1	4	1	5	1	1	2
Smooth cartilage	14	28	42	23	38	61	21	21	42	33	28	61
Mean incision length (Path. 1) (cm)	–	31	31	27	–	27	29	–	29	–	–	–
Mean incision time (Path. 1) (s)	–	18	18	23	–	23	20	–	20	–	–	–
Mean incision speed (Path. 1) (cm/s)	–	1.7	1.7	1.2	–	1.2	1.5	–	1.5	–	–	–
Mean incision length (Path. 2) (cm)	36	29	34	32	32	32	31	33	32	29	31	31
Mean incision time (Path. 2) (s)	16	14	16	18	12	16	10	15	13	5	12	10
Mean incision speed (Path. 2) (cm/s)	2.2	2.1	2.2	1.7	2.7	2.0	3.3	2.2	2.4	6.4	2.6	3.2
Mean incision length (Path. 3) (cm)	30	28	29	24	32	30	31	31	31	32	30	31
Mean incision time (Path. 3) (s)	18	16	17	16	19	18	26	28	27	13	15	13
Mean incision speed (Path. 3) (cm/s)	1.7	1.8	1.7	1.5	1.7	1.6	1.2	1.2	1.2	2.5	2.1	2.0
Mean incision speed (cm/s)	1.9	1.8	1.9	1.6	1.9	1.7	1.6	1.7	1.6	3.1	3.2	3.1
Fluid	1	0	1	2	1	3	1	2	3	2	0	2
Adhesions	1	1	2	1	1	2	3	0	3	1	0	1
Tumour	0	0	0	0	0	0	0	0	0	0	0	0
Spray	0	0	0	3	4	7	0	0	0	0	0	0
Organ damage	1	1	2	0	0	0	3	0	3	2	3	5
Approximate cost (£)			25			900			50			12

Path., pathologist; s, seconds.

male and female subjects. The men ranged from 29 to 90 years of age (mean, 70), had a mean height of 172 cm (range, 161–191), and a mean weight of 74 kg (range, 37–106). The women ranged from 38 to 90 years of age (mean, 67), had a mean height of 159 cm (range, 134–186), and a mean weight of 67 kg (range, 40–123). These are within the expected range for the adult population serviced by the Medico-Legal Centre, Sheffield.[8]

The mean incision length on the right side was 31 cm (range, 24–40), with a mean time taken to perform the incision of 17 seconds (range, 4–37; table 1). The mean times for pathologists 1–3 were 12 seconds, 18 seconds, and 22 seconds, respectively. The mean incision length on the left side was 31 cm (range, 24–38) with a mean time taken to perform the incision of 15 seconds (range, 4–23). The mean times for pathologists 1–3 were 13 seconds, 20 seconds, and 18 seconds, respectively. The overall mean times for pathologists 1–3 were 13 seconds, 19 seconds, and 20 seconds, respectively. The total number of ribs incised was 422. The total number of ribs that were incised through the bony portion was 206 (49%). Of these ribs, 137 (67%) had rough edges. This finding was instrument dependent, with 80% of bony ribs opened by the rib shears resulting in rough edges compared with 68% of those opened by a hand saw, 60% by the bread knife, and 51% by the electric saw. Figure 5 shows the frequencies of the incision sites selected by the pathologists when opening the chest wall.

When cutting through cartilage, all instruments except the rib shears produced a 95% or greater incidence of rib ends that were smooth. However, when using the rib shears only 89% of the ends were judged to be smooth. Overall, 95% of the cartilaginous parts of ribs that were incised produced smooth ends. The incidence of rough cartilage was low (10 of 422 ribs) and the rib shears alone accounted for 50% of such rib ends. No tumours were present within the pleural cavities. Adhesions were found in seven subjects and pleural fluid in six, with both occurring in two cases only. Spray occurred in 29% of the necropsies, with all cases occurring while using the electric saw. Organ damage was found in almost 11 subjects, with an approximately equal incidence on each side. The lungs were the most frequently damaged organs (eight) although the diaphragm (one), pericardial sac (one), and liver (one) were damaged in other cases. The highest frequency of such damage (half of the cases) was seen with the bread knife, the rib shears were second, and the handsaw third. Use of the electric saw was not associated with visceral damage.

DISCUSSION

This small sample study has confirmed that there could be a potential health risk associated with opening the thoracic cavity because of the high incidence of production of rough bony rib ends (one in three). We did not investigate glove injuries because we wanted to assess the potential risk rather than real injuries. Previous papers have drawn attention to the number and causes of glove injuries during necropsy and surgery.[9–11] The hands are not the only potential area of the body that may be injured by the rib ends. Because the forearms may also enter the chest cavity during the evisceration, they may also be exposed to and theoretically injured by the rib ends. To avoid this part of the body being injured one could wear a long sleeve surgical gown with separate plastic oversleeves.

The traditional hand saw appears to be a reliable method of opening the chest because it does not cause spray and has a low incidence of organ damage (one in six). Despite this observation, very few pathologists or mortuary technicians are trained in the use of this instrument these days, with most preferring alternative instruments. Ninety five per cent of cartilage incised with the handsaw was found to be smooth, and this instrument has the advantages of being affordable and easy to clean. However, 68% of incised bone was recorded as rough, although this was the second lowest rate after the electric saw. The electric saw produced the least number of rough cartilage and bony rib ends, with the incidence of rough bone being 51%. In addition, no incidents of organ damage were seen with this instrument. However, the electric saw produced spray in 60% of cases, and thus may pose a greater health risk as a result of aerosol production rather than sharp rib ends. The use of vacuum extraction systems reduces this risk, but it is also quite expensive (£500) and the system needs to be dismantled to be cleaned. If a pleural effusion is encountered the vacuum system may become contaminated with fluid, which necessitates the replacement of the paper filter system at an additional cost (R Start, personal communication, 2001). Alternatively, a face visor may be used, at a fraction of the price of the extractor, which although reducing the exposure to direct spray by the pathologist or mortuary technician does not reduce the risk of environmental aerosol production. The risk can be further reduced by the use of an appropriate particle filter mask and working within an environment with a down draft extraction system.

Take home messages

- Rib shears appeared to cause the highest frequency of rough, potentially dangerous rib ends
- The electric saw produced the smoothest rib ends, both in cartilage and bone, although it produced spray in just under a third of cases
- Each of the procedures had its own advantages and disadvantages, so that personal preference and operator experience are perhaps the most important factors

The rib shears are a relatively inexpensive instrument, although more expensive than two of the other postmortem tools. They cause no spray, are the fastest instrument in use, and are quite easy to clean. However, the rib shears caused organ damage in a quarter of cases, and half of the incised rib ends were rough, with more than three quarters of these being bony rib ends. This instrument also caused the highest rate of rough cartilaginous ends.

The bread knife is inexpensive, easy to maintain, and causes no spray. When cartilage was incised 97% had smooth ends, a greater percentage than that seen for the rib shears and the handsaw. It resulted in 60% of bony ribs being rough, second only to the electric saw. However, organs were damaged in 42% of cases and it was the slowest instrument to use.

The pathologists varied in the speed with which the incisions were performed. However, when the numbers of rough and smooth bony and cartilage ends were examined it was found that all pathologists conformed to the overall trend of the results. That is, rough cartilage occurred least often, followed by smooth bone, and rough bone, with smooth cartilage occurring most frequently. These findings support the notion that the resulting contour of the rib ends was dependent on the instrument used and not the person operating it.

Our study has shown that the opening of the thoracic cavity poses several problems that need to be considered to protect the health of the person performing the procedure. The lowest numbers of rough rib ends were produced when the incisions were made through the costal cartilages. However, this leads to a narrow work field, which may cause difficulties during evisceration. If a more lateral line of incision is used—for example, the anterior axillary line—the field of work becomes greater but the risk of injury as a result of irregular rib ends increases. Rib shears, the most frequently used instrument in current mortuary practice, appear to produce the worst results. The electric saw seems to be the instrument of preference, although a vacuum extractor that attaches to

the saw (to reduce the spray, which may pose a significant health hazard) needs to be purchased, and this has an added cost implication. Ultimately, it may be personal preference and familiarity with a particular method or instrument that determines which is used but we feel that our study provides a rational basis for instrument selection when safety is of prime concern.

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